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HABITAT SAMPLING AND SELECTION BY FEMALE WILD TURKEYS DURING PREINCUBATION

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ABSTRACT.—Habitat use and home range sizes of female Eastern Wild Turkeys (*Meleagris gallopavo silvestris*) during preincubation may influence reproductive success. Little information on habitat selection during preincubation at multiple spatial scales is available and the influence of preincubation movement rates on reproductive success is poorly understood. We monitored 35 adult female Eastern Wild Turkeys during preincubation in central Mississippi during 1996–1997. We estimated home range and core area size, macrohabitat selection at multiple spatial scales and movement rates from 1 February until the beginning of incubation. Preincubation home ranges averaged 306.6 (±46.8 SE) ha and core areas 47.3 (±7.4) ha. Females selected 9–15 and 16–29 year-old pine (*Pinus* spp.) stands over other habitats available when establishing home ranges, but within these home ranges they selected pine stands that were older than 30 years for their core areas and nest sites. However, females used habitats within their established home range in proportion to availability. Movement rates averaged 286.5 (±22.3) m/hr during preincubation and were greater than during other seasons. We detected no correlations between home range or core area size and number of days nests were successfully incubated. However, we detected a positive correlation between movement rates and increased incubation, suggesting females that moved farther during preincubation successfully incubated nests longer. Our findings suggest females selected habitats differentially when establishing pre-incubation home ranges and core areas. Further, our findings suggest movement rates within home ranges may better reflect a female's habitat sampling effort during nest site selection rather than home range or core area size. *Received 17 Jan. 2000, accepted 10 April 2000.*

Reliable estimates of home range size are essential for understanding a species' behavioral ecology (Bekoff and Mech 1984). Areas of concentrated use within home ranges are often denoted as core areas (Kaufmann 1962), implying that these areas are preferred (Leuthold 1977). Non-migratory species should establish home ranges and select habitats that best meet their ecological requirements in the smallest possible space. Individuals should preferentially select portions of the landscape that enhance their survival and reproduction (Pulliam 1988). Specific to Eastern Wild Turkeys (*Meleagris gallopavo silvestris*), selection of suitable nest habitat, as determined by distribution of suitable nesting sites (Badyaev 1995), often requires extensive movement and increases in home range size relative to other activities (Badyaev et al. 1996a). Numerous researchers have examined seasonal home ranges in Wild Turkeys (e.g., Porter 1977, Smith et al. 1989, Kurzejeski and Lewis 1990); however, few have documented core area sizes, particularly during preincubation. Although home range size might influence reproductive success of Wild Turkeys (Badyaev et al. 1996a), the effect of variation of core area characteristics is unclear.

Habitat selection can influence survival and reproduction (Cody 1985, Badyaev et al. 1996b). During preincubation, female Wild Turkeys presumably shift habitat use to sample areas within their home range prior to nest initiation (Miller et al. 1999), assuming movements are not strongly influenced by interactions with other females or male display behaviors. Although Wild Turkey macrohabitat use has been extensively documented (Everett et al. 1985, Lambert et al. 1990, Speake et al. 1975, Wigley et al. 1986) and the need to examine habitat use at multiple spatial scales is recognized (Johnson 1980, Orians and Wittenberger 1991), little research has been directed towards Wild Turkey habitat selection at multiple spatial scales. Specifically, assessments of female habitat selection at multiple spatial scales during pre-incubation are scarce (Miller et al. 1999) and no study has examined selection processes at the core area level.

Variation in habitat quality across landscapes should favor individuals that select habitats providing the greatest reproductive

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success (Fretwell and Lucas 1970). In general, increased search time should increase the probability of selecting a better quality habitat (Stephens and Krebs 1986, Orians and Wittenberger 1991). Badyaev and coworkers (1996b) determined that increased habitat sampling (measured via preincubation range) allowed female Wild Turkeys to select higher quality nest sites, thereby increasing nest survival.

We evaluated spatial use characteristics, macrohabitat selection at multiple spatial scales, and movements during preincubation, and relationships among spatial use patterns, movements, and nest survival for female Wild Turkeys. Our objectives were to (1) examine spatial use characteristics (home range and core area sizes) during preincubation, (2) examine macrohabitat selection processes during preincubation at 3 spatial scales, (3) estimate seasonal movement rates, emphasizing movements during preincubation, and (4) assess relationships among spatial use patterns, movements, and nest survival for female Wild Turkeys in central Mississippi.

STUDY AREA AND METHODS

We conducted this research on the 14,410 ha Tallahala Wildlife Management Area (WMA), a 2,500-ha area owned by Georgia-Pacific Corporation and surrounding private lands in sections of Jasper, Newton, Scott, and Smith counties, Mississippi (89° 24′ N, 32° 15′ W. to 89° 04′ W 32° 05′ W). The Tallahala WMA contained 30% mature (>30 years old) bottomland hardwood [oak (*Quercus* spp.), hickory (*Carya* spp.)] forests, 37% mature pine (*Pinus taeda, P. echinata*) forests, 17% mixed pine-hardwood forests, and 11% in 1–15 year-old loblolly pine (*P. taeda*) plantations. The Georgia-Pacific area was adjacent to Tallahala WMA and was managed primarily for wood fiber production with 90% of the area comprised of 1–35 year-old loblolly pine plantations and the remaining 10% in Streamside Management Zones along creek drainages. Private lands were comprised mostly of mixed pine-hardwood and short-rotation pine forests. Topography was gently to moderately rolling, with 0–20% slope. Climate was mild, with a mean annual temperature of 20° C and mean annual precipitation of 152 cm.

We captured female Wild Turkeys with cannon nets on bait sites established during January–March 1996–1997 and July–August 1996. Capture sites were evenly distributed throughout the study area to ensure unbiased sampling of the population. Females were aged following Hewitt (1967). Captured adult females were tagged patagially (Knowlton et al. 1964), fitted with 85–100 g mortality sensitive radio-transmitters attached backpack style, and released at the capture site.

We located females by triangulation (White and Garrott 1990) using a hand-held 3-element Yagi antenna from predetermined telemetry stations (n = 480) at least five times/week. In most (98%) instances, distance from observer to female was within 1.0 km. We used two telemetry techniques to monitor females: systematic point and sequential locations. We obtained systematic point locations by recording two locations weekly for each female. We conducted sequential telemetry (focal runs) on a 4 hour basis with a location recorded on each female every hour for the entire 4 hour period. Azimuths for a single radio location were recorded within a 15 minute interval to reduce error caused by female movement; however, most (97%) consecutive azimuths were recorded within 7 min [$\bar{x}$ = 4.6 min ± 0.02 (SE)]. Triangulation angles were maintained between 45° and 135° to reduce error and telemetry accuracy tests indicated that standard deviation from true bearing was 5.7°. Therefore, a circle circumscribing each female's location 1 km from each telemetry station would have an approximate area of 3.3 ha. Because the smallest macrohabitat patch on the study area was more than 5 ha and most (98%) locations were recorded within 1 km of each female, we assumed telemetry accuracy was sufficient for our analyses. To determine onset of incubation, hens located in the same location for two consecutive days were considered incubating, particularly when roosting did not occur.

Home range and core area analyses.—Female locations were entered into a dBASE III+ database and converted to a coordinate system using program TELEBASE (Wynn et al. 1990). We defined the preincubation season as 1 February to initiation of incubation. Home range (95%) and core area (50%) contour intervals were estimated using an adaptive kernel estimator in program CALHOME (Kie et al. 1994). Area observation curves conducted on five randomly chosen females indicated 32 locations were needed to estimate home range and core area sizes during preincubation. Therefore, we only estimated home ranges and core areas for females sampled with a minimum of 32 locations and for at least 75% of the preincubation season.

Movement rates.—We estimated movement rates (m/hr) by dividing the straight-line distance between sequential locations by the time interval. Only locations separated by less than 1.25 hours were used to ensure that distances between locations were associated with actual distances moved (Reynolds and Laundré 1990). We examined movement rates seasonally and considered the seasonal movement rate for each female as the experimental unit in analyses. To compare movement rates during preincubation to other seasons, we monitored females throughout the annual cycle and defined the remaining seasons as nesting (nest initiation–termination of nesting effort), brood-rearing (termination of nesting effort–30 September), and fall-winter (1 October–31 January). We used a one-way

ANOVA blocked by year to examine potential differences in movement rates across seasons and LSD multiple comparisons to test differences in mean separation of movement rates using SAS Version 6.12 (SAS Institute 1996). For home range, core area, and movement analyses, we tested homogeneity of variance using Levene's test (Milliken and Johnson 1992) and we used the Shapiro-Wilk statistic (Steel and Torrie 1980) to test for normality.

We used correlation analysis to test the hypothesis that female movement rates within preincubation home ranges were related to nest survival (days successfully incubated). Similarly, we used Pearson's correlation analysis to test the hypothesis that nest survival was related to preincubation home range or core area size.

Macrohabitat use.—We developed a Geographic Information System (GIS; ARC/INFO; ESRI, Redlands, California) with color infrared aerial photographs and 1:24,000 U.S. Geological Survey 7.5-min quadrangles. The U.S. Forest Service records from Bienville National Forest and stand data from Georgia-Pacific were used to classify stands into habitat types based on forest type (i.e., hardwood, pine) and stand age. We used year-specific stand maps and data to create two annual habitat coverages for the entire study area. We used aerial photographs, ground surveys, and landowner consultations to quantify habitat type on private lands within and surrounding the study area.

We delineated habitats as: mature (≥30 years) hardwood, mature mixed pine-hardwood, three classes of pine regeneration (0–8 years, 9–15 years, 16–29 years), mature pine (≥30 years), and other habitats (agricultural and Conservation Reserve Program lands ≤2 years old). Preincubation habitat use was investigated at 3 levels: (1) habitat use within home ranges versus availability of habitats across study area (first order), (2) habitat use in core areas versus availability of habitats within home range (second order), and (3) habitats used within home range versus availability of habitats in home range (third order). The outer boundary of our study area and study area habitat availability were determined using a buffer system around roads used for trapping Wild Turkeys during the study. We used the major axis length of the largest preincubation home range to buffer the road system in ARCVIEW (ESRI, Redlands, California). We estimated study area, home range, and core area habitat availability by summing the area for each habitat and dividing it by the total area of the study area, home range, or core area. We used compositional analysis (Aebischer et al. 1993) to examine pre-incubation habitat selection. After blocking by year, we tested differences of log-ratio habitat use and availability percentages with a multivariate analysis of variance (MANOVA) in SAS Version 6.12 for Windows 95 (SAS Institute 1996). We also calculated a mean rank for each habitat type within each scale of selection to provide an overall assessment of the importance of each habitat type. If significant differences were detected between habitat selection and availability at any scale, a ranking matrix of *t*-tests was constructed to examine order of selected habitat (Aebischer et al. 1993).

Nest survival and success.—After 5 days of incubation, nests were approached to within 50 m and azimuths were taken towards the nest from several points around it. After cessation of nesting activity, nests were located using marked reference points to determine nest fate. We calculated nest survival by recording the number of days females successfully incubated nests prior to nest loss or hatch. We defined nesting success rate as the proportion of hens initiating incubation that successfully hatched at least 1 egg.

RESULTS

We monitored 2319 locations of 35 females to estimate home range, core area size, macrohabitat use, and movement rates during preincubation. We monitored 2600 locations of incubating females. Thirty-three females were relocated enough times to estimate home ranges and assess habitat selection. Two females could not be monitored intensively because of radiotransmitter failure midway through the preincubation period. Number of relocations/female averaged 58 during preincubation. Home range and core area sizes averaged 306.6 (±46.8) ha and 47.3 (±7.4) ha, respectively.

Macrohabitat use.—Differences in use and availability differed at first order selection ($F_{6,31}$ = 7.5, $P < 0.001$), indicating females used habitats different from availability of habitats across the study area, selecting 9–29 year old pine stands over other habitats (Table 1). Differences in use and availability also differed at second order selection ($F_{6,31}$ = 3.88, $P = 0.005$), indicating females used habitats at the core area level different from the availability of habitats within the home range. Females selected mature pine stands over other habitats. However, differences in use and availability were not different at third order selection ($F_{6,25}$ = 0.55, $P > 0.05$), indicating females used habitats within home ranges similar to the proportion of those habitats.

Nest survival and success.—Nest initiation rates averaged 73% during 1996 and 87% during 1997. Only 2 females renested during this study; neither was successful. Estimates of nest survival averaged 14.2 days and nest success averaged 10%.

Movement rates.—Movement rates differed across seasons ($F_{3,108}$ = 14.83, $P < 0.001$). Females moved at greater rates during prein-

TABLE 1. Mean ranks (1 = least, 7 = greatest) of habitat use across 3 spatial scales based on compositional analysis for adult female Eastern Wild Turkeys during preincubation on Tallahala Wildlife Management Area, Georgia-Pacific Corporation, and surrounding private lands, Mississippi, 1996–1997.

	Order of habitat selection[a]			
Habitat type	1st	2nd	3rd	Overall
Mature hardwood (≥30-yr-old)	1	6	5	4.0
Mature mixed pine-hardwood (≥30-yr-old)	5	3	3	3.7
Pine (0–8-yr-old)	3	1	1	1.7
Pine (9–15-yr-old)	6	2	2	3.3
Pine (16–29-yr-old)	7	5	6	6.0
Mature pine (≥30-yr-old)	2	7	7	5.3
Other (agricultural areas, openings)	4	4	4	4.0

[a] 1st order—habitat selection across home range versus availability of habitats across study area; 2nd order—habitat selection in core areas versus availability of habitats within home ranges; 3rd order—habitats used within home range versus availability of habitats in home range.

cubation ($\bar{x}$ = 286.5 m/hr ± 22.3) than during brood-rearing (only non-brooding females; $\bar{x}$ = 201.3 m/hr ± 10.6), fall-winter ($\bar{x}$ = 198.7 m/hr ± 40.1), or nesting ($\bar{x}$ = 122.8 m/hr ± 15.4).

Relationships between spatial use patterns, movements, and nest survival.—We did not detect correlations between preincubation home range size (r = 0.216, $P > 0.05$, n = 21) or core area size (r = 0.124, $P > 0.05$, n = 21) and duration of nest survival. However, duration of nest survival was positively correlated to preincubation movement rates (r = 0.468, P = 0.037, n = 21).

DISCUSSION

Variability in habitat quality should favor individuals choosing habitats producing greater survival and reproductive success (Fretwell and Lucas 1970). Habitat sampling (i.e., movements) by females during preincubation should decrease with increasing habitat quality or decreased variability (Stephens and Krebs 1986). In turn, female movements (i.e., habitat sampling) could be influenced by the spatial distribution of resources, experience or age, or perhaps physiological condition of the female. Renesting effort on the study area is considerably lower than in other areas of Eastern Wild Turkey range (Miller et al. 1998, this study); thus, initial nesting efforts constitute the majority of reproductive efforts for this population. Therefore, reproduction on our study area is temporally limited in that females usually invest considerable resources into only a single clutch. Because females should preferentially select portions of the landscape optimizing reproductive potential (Fretwell and Lucas 1970), we predicted females would exhibit greatest habitat sampling prior to nest initiation, presumably to locate a nest site that increased probability of nest survival. Our findings supported this prediction, because female movement rates were greatest during preincubation compared to other seasons. However, female home ranges were not seasonally largest during preincubation (Chamberlain 1999), suggesting that females did not necessarily increase the portion of the landscape they sampled but rather intensified sampling efforts within established home ranges prior to nest initiation.

Females selected 9–29 year-old pine stands at the home range level, but selected mature pine stands at the core area level. Additionally, mature hardwood stands were consistently ranked higher than other habitat types, except mature pine, at the core area scale of selection. Selection of mature pine stands likely resulted from an increased availability of quality nest sites because microhabitat characteristics in mature pine stands were desirable for nesting (Chamberlain and Leopold 1998). Most nest attempts on the study area occurred in mature pine stands or pine regeneration areas (Miller et al. 1999) and nesting success was greatest in mature pine stands compared to other available habitats (Seiss et al. 1990). Many mature pine stands were intensively managed (i.e., thinned and prescribe burned) for Red-cockaded Woodpeckers (*Picoides borealis*) during our study. These stands contain more herbaceous vegetation, a key component of nest sites on our study area, relative to other stands (Palmer et al. 1996). Pine stands receiving prescribed fire on a 2–4 year rotation also provided quality brood-rearing habitat (Phalen et al. 1986). Therefore, females selecting mature pine stands within core areas during preincubation are reproductively adaptive, both for nesting and brood-rearing.

Females used habitats similar to their availabilities within their home range. Our findings suggest females selected home ranges and core areas based on a defined proportion of habitats, but sampled those habitats similar to availability within these areas, suggesting the use of multiple scales of selection during preincubation. The nondifferential use of habitats within home ranges also suggests females distribute sampling intensity across habitats within their home range, presumably to locate a nest site with a particular suite of habitat characteristics.

Badyaev and coworkers (1996b) and Miller and coworkers (1999) indicated successful females used areas within their home range differently than unsuccessful females. Regrettably, nest success in this study was very low, and given the large proportion of unsuccessful females in our marked population, examining potential differences in habitat selection between successful and unsuccessful females was not possible. We encourage other researchers to examine relationships between habitat sampling and reproductive success in other areas of Eastern Wild Turkey range.

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